THE VALUE OF SUPPLEMENTAL TRACE MINERALS IN CATTLE FATTENING RATIONS

by

BOBBY DERYLE CARMACK

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INTRODUCTION

The importance of the mineral elements for normal functions of the body have been recognized for many years, yet the actual role in which most of them specifically act has not been fully explained. According to Morrison (1959), thirty years ago knowledge was very limited concerning the exact amounts required, and very little was known about the need for any of the minerals. Since that time, deficient areas have been discovered along with areas that contain toxic levels. These discoveries have caused much concern in the use of minerals, and have lead to extensive use of mineral supplementation in livestock feeding.

The minerals number thirty plus, but less than one half this number have been found to be essential for life. These minerals may be divided into two categories, depending on their requirements. Those that are required in substantial quantities are called the macro elements or major minerals and include calcium, phosphorus, potassium, sodium, chlorine, magnesium, and sulfur The mineral elements required in small, or minute quantities are termed trace minerals or the micro elements, and include some twenty plus in number, occuring in amounts of less than .005 per cent of the body according to Elvehjem (1954). Only eight of these were considered to be important to ruminating animals. They were copper, cobalt, manganese, iron, iodine, zinc, molybdenum, and flourine. An excess of some of these elements may be toxic.

Previous experiments conducted at this station have shown that trace minerals added to fattening rations, where corn was the grain component, improved the performance of the animals by an increase in daily rate of

gain, feed efficiency and in some cases, carcass improvement. It was of interest to note that when sorghum grain was substituted for corn as the grain in these rations there was no significant improvement in performance.

The experiments reported here were conducted to study the effect of adding a combination of the trace minerals, copper, cobalt, iron, manganese, zinc, and iodine to cattle fattening rations. The rations were composed of prairie hay, soybean meal, ground limestone and either corn or sorghum grain.

REVIEW OF LITERATURE

Copper

Hart et al. (1928) discovered that a small amount of copper was necessary for hemoglobin formation, along with iron. It was not a constituent of hemoglobin according to Dukes (1955) but catalyzed hemoglobin formation and erythropoiesis and occured in a copper-protein compound called hemocuprien in the blood cells. It was also present in all living matter, although its functions were not fully understood. Maynard and Loosli (1956) reported that approximately one half of the copper in the body was in the muscles. It was stored mainly in the liver and also in the bone marrow, spleen, and other organs. Dukes (1955) stated that blood contained .1 milligram of copper per 100 mililiters blood, the concentration being about equal between the plasma and the cells. Crampton and Lloyd (1959) reported that its role as a component of enzymes and/or activator of enzymes was probably more important than its role in hemoglobin formation. It was a component of ascorbic acid oxidase, tyrosinase, cytochromes, catalases, amylases, hydroperoxidases, and other

enzymes. A deficiency of copper resulted in a microcytic hypochromic anemia due to a decreased absorption of iron, lowered body content of iron, and a decrease iron mobilization from the tissues according to Maynard and Loosli (1956) and Davis (1951). The injection of iron, failed to correct this, and indicated that copper was responsible. Hawk, Oser, and Summerson (1954) reported that a copper deficiency was actually nothing more than an iron deficiency. Crampton and Lloyd (1959) stated that "swayback" disease of new born lambs in England was a result of copper deficient diets; although the copper was available in the plants, it was not utilizable and supplemental copper was needed. Cunningham (1944) reported that falling disease or "ezootic ataxia" in Australia was a copper deficiency, resulting in the animal staggering, falling, and often dying. Peat scours of New Zealand have been traced to a high molybdenum, low copper ratio in the diet. Davis (1951) stated that Florida "salt sick" was caused, at least partly by a copper deficit. Depigmentation of hair has been widely reported as a copper deficiency according to Maynard and Loosli (1956).

A metabolic interaction between copper and molybdenum may occur under practical conditions, according to Dukes (1955). High intake of molybdenum reduced copper absorption and storage, and low intakes of molybdenum. where copper content was normal or high, may lead to increased copper storage, resulting in chronic copper poisoning. Copper levels of 100 milligrams daily were toxic to adult sheep, according to Crampton and Lloyd (1959).

The National Research Council (1958B) recommended 4-8 parts per million of copper, air-dry ration basis, to meet the body's requirement

for copper. Davis (1951) stated that copper, along with cobalt, was probably present in feeds in insufficient amounts throughout the United States to meet animal requirements. The copper requirement was reported to be approximately one tenth that of iron by Maynard and Loosli (1956).

Cobalt

Cobalt is one of the most recent minerals discovered to be essential to ruminants. It has been found to be essential for the synthesis of vitamin B12 by the rumen microflora and Davis (1955) reported that it was necessary in the diet of ruminants to prevent progressive emaciation and anemia.

The B12 molecule contained approximately four per cent cobalt, stated Todd (1959). Maynard and Loosli (1956) stated that there actually was not a cobalt deficiency in animals, but a vitamin B12 deficiency due to a lack of cobalt. Crampton and Lloyd (1959) reported that cobalt was an activator of the enzymes arginase, dipeptidas and phosphoglucomutase. They stated that deficiency symptoms of cobalt as; long, rough hair coat, scaly skin, absence of estrus, abortion, low milk production, loss of appetite, loss of weight, anemia, depraved appetite, and if severe enough, death may follow. Anemia, resulting from cobalt deficiency was different from anemia caused by copper and iron deficiency being of the normocytic, normochronic type.

A fatty degeneration of the liver and deposits of hemosiderin in the spleen were commonly found changes in the case of a cobalt deficiency, according to Maynard and Loosli (1956). Davis (1951) reported that a deficiency of cobalt in Florida caused lower production, a smaller calf

crop, and less resistance to disease.

Morrison (1959) reported that supplemental cobalt given to deficient animals resulted in a marked improvement in appetite in three to seven days. Oral administration of cobalt, and vitamin B12 administered intra parenternally, were effective treatment in a deficiency state, according to Todd (1959). Supplying cobalt to sheep and cattle rumens increased their production of vitamin B12 according to Hawk, Oser and Summerson (1954) and Bently et al. (1954).

Elvehjem (1954) stated that animals receiving a high starch diet were apt to develop a cobalt deficiency. Maynard and Loosli (1956) stated that milk and some of the cereal grains were deficient in cobalt content.

The National Research Council (1959) reported that corn was considerably lower in cobalt than sorghum grain according to their published tables and recommended .07 - .10 milligram of cobalt per one hundred pounds body weight in their bulletin (195B) (approximately .03 - .05 milligram per pound of feed). Maynard and Loosli (1956) reported that excess cobalt was toxic, but not practical under normal conditions.

Iron

Maynard and Loosli (1956) reported that the body contained only .004 per cent iron, however it was very necessary for the normal function of the body. It was a constituent of the respiratory pigment, hemoglobin, and therefore was essential for function of every part of the body. Hemoglobin contained .34 per cent iron according to Dukes (1955), and

iron was a constituent of the oxygen carrier and also of oxidizing catalystsor enzymes. Iron content of blood according to Underwood (1956) was .30 - .59 per cent of the blood volume. Elvehjem (1954) stated that iron had been recognized as a constituent of blood since the early 1700's.

Hemoglobin has been described by Dukes (1955) as a respiratory pigment in the blood composed of a conjugated protein along with iron. It accounted for over 50 per cent of the body's iron and upon hydrolysis liberated globin (96 per cent), and heme (four per cent) which was on iron containing porphyrin ring compound. Iron was also found in myoglobin, in the muscle; siderophilin in the plasma, cytochrome C, peroxidases, catalases, and other enzymes according to Maynard and Loosli (1956).

Iron was stored in the liver primarily and secondarily in the spleen and kidneys and its synthesis into hemoglobin occurred throughout life, reported Crampton and Lloyd (1959) who also stated that functional iron, stored in the liver was called ferritin, and iron-protein complex containing 20 per cent iron.

Milk, according to Underwood (1956) was an extremely poor source of iron, containing only .3 - .6 milligrams of iron per liter of milk. Infants were found to have an additional iron reserve in the liver, which was later used for hemoglobin synthesis to supplement the low iron content of their milk diet, according to Hawk, Oser and Summerson (1954). Most other foods, with this exception, contained ample iron for the body's needs, since only a small portion of the body's iron was lost under normal conditions. Dukes (1955) stated that as hemoglobin was broken down in the reticuloendothelial system, it went into storage in the liver and spleen, and was transported to the bone marrow to be reutilized in

hemoglobin formation. The chief need for iron appeared to be for young animals on a milk diet or in others after blood loss, stated Hawk, Oser and Summerson (1954).

A deficiency of iron results in a microcytic hypochromic anemia due to a lack of functional iron for the building of hemoglobin. Iron deficiency is represented by the anemia which often occurs in suckling pigs, termed "thumps", which is actually a lack of sufficient iron for hemoglobin formation, therefore overworking the heart.

The requirement for iron should be measured as the amount needed to maintain a normal hemoglobin level and to retain an appropriate positive level, according to Maynard and Loosli (1956). Todd (1959) stated that growing, suckling pigs needed seven milligrams of iron daily. It must be remembered that small, minute amounts of copper are necessary for the utilization of iron in the body. Davis (1954) reported that Florida had trouble due to low iron content of roughage, when roughage made up approximately two-thirds of the ration of cattle and sheep. However, certain "so-called" iron deficiencies have responded to supplementation of copper and/or cobalt. The National Research Council (1958B) has recommended less than fifteen milligrams per pound of feed to meet animal requirements. Crampton (1956) recommended that .002 per cent of the dry feed should be iron, or 28 milligrams per kilogram body weight. Maynard and Loosli (1956) stated that excess iron interfered with phosphorus absorption by forming an insoluble phosphate and rickets may result. Iron deficiency in mature animals has been reported as unusual, under normal farm conditions.

Manganese

Trace amounts of manganese have been reported as occuring in practically all tissues of the body in small amounts. Crampton and Lloyd (1959) stated that the most important apparent function of manganese in the body was as an activator of enzymes concerned with carbohydrate, fat, and protein metabolism, such as carboxylases, dehydragenases, esterases and peptidases. Arginase contains trace amounts of manganese. Maynard and Loosli (1956) stated that the trace amounts of manganese in the body were principally stored in the liver although appreciable amounts were present in the skin, kidney, muscle, and bone.

The functions of manganese have been poorly understood, but evidence indicated that it was necessary for proper bone formation, growth and reproduction, according to Dukes (1955).

Todd (1959) stated that certain corn products have been found to be low in manganese. Manganese deficiency in females caused late sexual maturity, irregular ovulation and weak young at birth; while in males, sterility due to germinal degeneration was the result of a manganese deficient diet, according to Crampton and Lloyd (1959). Maynard and Loosli (1956) reported that a manganese deficiency in chicks caused perosis or "slipped tendon", and malformed bones. Elvehjem (1954) stated that the manganese to iron ratio was .1 - 10.

The National Research Council (1958B) reported that the requirement for beef cattle was met by 2.7 - 4.5 milligrams of manganese per pound of air dry ration. Under practical conditions, this requirement may be easily met by feeding of regular ration components.

Zinc

Zinc composed three milligrams per cent of the body and was a component of several enzymes. It was found in all animal cells with the larger amounts occuring in the bones, teeth, hair and skin. It was next to iron in abundancy in the body and although its functions were poorly understood, it was a component of the enzymes; carbonic anhydrase, uricase, kidney phosphatase, and has been found in crystalline insulin according to Hawk and Summerson (1954) and Dukes (1956). The respiratory enzyme, carbonic anhydrase, was .3 per cent zinc, and indicated the essentiality of zinc in the body.

Deficiency of zinc in swine rations may result in a condition known as parakeratosis, a disease characterized by skin lesions, diarrhea, vomiting and anorexia according to Maynard and Loosli (1956). This apparently was caused by a high calcium low zinc ratio in the body. Dukes (1955) stated that alopecia and emaciation were results of a zinc deficiency in the body. Excess zinc may interfere with the functions of copper, causing an anemia, which can be relieved by feeding extra copper. The presence of zinc, according to Crampton and Lloyd (1959) interfered with the action of the two female reproductive hormones, the follicle stimulating and the lutinizing hormones.

Zinc has been reported as widely distributed in the plant kingdom and therefore not a great problem in ruminant rations. Davis (1951) reported that rations containing not more than .19 parts per million did not interfere with normal development.

Iodine

Iodine made up .00004 per cent of the body weight and approximately 60 per cent of it was located in the thyroid gland according to Crampton and Lloyd (1959) and Maynard and Loosli (1956). Morrison (1959) stated that iodine was necessary for all animals because the rate of metabolism of the body was controlled through the action of an iodine containing hormone, produced by the thyroid called, thyroxine. If sufficient iodine was not supplied in the diet the thyroid gland would enlarge, trying to overcome its deficiency, and the end result would be goiter. This was usually more prevalent in young animals.

Certain areas of the United States are known to be deficient in iodine, primarily in the Great Lakes Region and westward toward the Pacific Coast.

Soybeans, cabbage and turnips promote goiter by containing an anti-thyroid principle that slows down thyroid activity according to Maynard and Loosli (1956). Thyroidectomy of young animals results in a stunting of physical, mental, and sexual development, along with a lowered basal metabolism.

Iodine deficiency resulted in retarded growth, depigmentation of hair coat and although it was necessary in only minute quantities, the required level must be maintained or disaster results. Mature animals contained less than one part iodine in three million parts of body weight, according to Morrison (1959). The addition of iodine, when not required, has been reported as of little value and even in iodine deficiency trials the benefit was usually slight, performance wise. When supplying iodine

in the diet, it must be remembered that it need not be supplied each day, for the thyroid gland has a great storage place for iodine. Maynard and Loosli (1956) recommended .002 - .004 milligrams of iodine per kilogram of body weight. Excess amounts of iodine can result in goiter.

Supplementing Rations with Trace Minerals

In recent years considerable work has been done in an attempt to determine the value of supplemental trace minerals in rations. The results have been conflicting, probably due to differences in mineral content of the soils upon which the feed was grown, management of animals and other environmental aspects.

Chappel et al. (1952), working with lambs to determine the effect of minerals on digestibility of a low quality ration of: corn cobs (45 per cent), ground yellow corn (25 per cent), corn gluten meal (20 per cent), corn syrup (seven per cent), and corn oil three per cent), reported that the minerals supplied by adding alfalfa ash improved the apparent digestibility. Tillman et al. (1954) reported that the addition of alfalfa ash or trace minerals to a prairie hay ration for lambs did not improve the apparent digestibility. Summers et al. (1957) stated that the addition of trace mineral supplement was as effective as alfalfa ash in acquiring optimum cellulytic activity in the rumen on rations consisting of 65 per cent corn cobs and 18.6 per cent corn starch. Hubbert et al. (1958) reported that copper, cobalt, and zinc depressed cellulose digestion in the rumen. The literature, thus far, indicates that apparent digestibility may or may not be improved by the addition of trace minerals.

Bently, et al. (1952) working with cattle on a semi-synthetic ration of urea, ceralose, iodized salt, limestone, calcium phosphate, vitamin A and D oil, corn and cob meal and poor quality, late cut timothy hay, over a 140 day period reported that the addition of trace minerals (copper, cobalt, manganese, zinc and iron) improved the daily gains by 43 per cent over the controls. This was an increase in gain from 1.34 pounds per day (basal) to 1.92 pounds per day, a difference of 0.58 pounds per head a day. The trace mineral mixture saved twelve per cent of the corn and cob meal per 100 pounds gain. The lot receiving trace elements consumed on the average 25 per cent more corn and cob meal daily, indicating an improved appetite. The hematocrit of both lots were within normal ranges. Beeson and Perry (1952) reported that steers may be fattened on a roughage ration of corn cobs, if properly supplemented with minerals, vitamins and protein, with average daily gains of 2.3 pounds.

Sellers, et al. (1960) at Oklahoma reported that no response was obtained when trace minerals were added to a ration of sorghum grain, cotton seed hulls or sorghum silage, soybean meal or urea, bonemeal and limestone. Pope, et al. (1959) feeding milo, silage and soybean oil meal in a fattening ration for yearling steers stated that added trace minerals did not improve the performance of the steers. Feeding roughage rations, Nelson, et al. (1952) feeding beef heifers and Nelson (1955) feeding stocker cows did not receive any added benefit from feeding trace minerals increased the summer gain by twenty pounds per head but the yearly gain was approximately equal. Pope, et al. (1951) in wintering steers on native grass (Buffalo and Gramma) in Oklahoma reported that

supplemental trace minerals added to a protein supplement of cottonseed meal did not improve daily gains of the steers; but, trace minerals, when added to soybean meal, improved the daily gains considerably. Pope, et al. (1952) working again with steers on native grass, supplemented with cottonseed meal or soybean meal reported that trace minerals did not improve the performance of the steers.

Dent, et al. (1956) in Oregon, fed grass silage, molasses, oats and barley hay (limited), dicalcium phosphate, steam bonemeal, and salt to beef heifers with and without added trace minerals. The control group gained 1.76 pounds per head daily while the group receiving trace minerals (free choice) gained 2.11 pounds per head daily, a difference of 0.35 pounds per head per day. The addition of trace minerals also increased the total ration consumption. The trace mineral mix consisted of copper, cobalt, and manganese, with these amounts in milligrams per head daily respectively; 60, 17.3, and 0.6.

Plumlee, et al. (1953) fed identical twins corn cobs with added trace minerals. The trace minerals depressed the appetite and therefore controlled the intake. Gossett and Riggs (1956) reported that the addition of trace minerals to poor quality prairie hay rations did not change the performance of the cattle. Dowe et al. (1956) stated that steers on a high roughage ration of brome grass hay, limited corn and soybean meal fed to six different lots received no added response when the trace minerals cobalt, copper, manganese, iron, iodine, and zinc were fed in a salt mixture. Klosterman, et al. (1956) and Bently, et al. (1952) feeding poor quality timothy hay in a fattening ration of ground ear corn, and corn and cob meal reported that the addition of trace

minerals improved the daily gains and increased the daily feed consumption. Klosterman, et al. (1953), also using poor quality hay, used a trace mineral mixture which supplied the animal 800 milligrams of iron, 200 milligrams manganese, 25 milligrams copper, fourteen milligrams zinc and 0.5 milligrams of cobalt daily. The gains of the trace mineral lots were improved 0.24 pounds per head daily over the control lot. Bently et al. (1954) using a trace mineral mixture to supplement a fattening ration of ground ear corn and poor quality chopped hay for 140 days reported a difference of 0.62 pounds per head daily and 80 pounds less feed per 100 pounds weight gained. The cattle deficient in trace minerals were of poor growth and suffered from anorexia. A deficient lot of cattle was then given supplemental cobalt alone and another lot a trace mineral mixture for 84 days and in both lots daily gains were improved more than 0.5 pounds per head per day. Feed analysis of the basal ration indicated that the benefit might be attributed to cobalt, since the average cobalt content of the ration was only 0.03 - 0.04 parts per million. The results of these experiments indicated that the poor quality hay fed was probably deficient in one or more of the necessary trace minerals, and that the trace minerals present in the supplement were the main contributing factors for increased daily gain and feed efficiency according to the researchers. Klosterman, et al. (1953) stated that poor quality hay plus added trace minerals was not equal to good quality hay.

Smith, et al. (1955) reported that supplemental trace minerals added to a roughage ration did not improve the performance of the cattle. Smith, et al. (1954), supplementing a fattening ration of corn, reported an increase in gain of 0.58 pounds per head daily, and stated that most

of the increased gain occured in the first thirty days of the trial. Oltjen, et al. (1959), in summarizing four trials done in Kansas, reported that the addition of trace minerals; copper, cobalt, iron, manganese, iodine and zinc to a fattening ration of sorghum grain, prairie hay, soybean meal and limestone produced no response. He stated that the addition of trace minerals to a fattening ration similar to the one above but with corn replacing sorghum grain, increased the daily gains by 0.47 pounds per head daily, the heifers ate more grain, used it more efficiently, and had slightly higher grading carcasses with slightly more marbling in one trial.

Swenson, et al. (1956) reported that trace minerals when added to the diet of Hereford heifers had little effect on their performance, however, their hair coats and general appearance were improved when poor quality roughage was fed. Jones (1956) supplemented a calf ration with selected trace minerals and reported that it increased their size, but with little effect after eight weeks of age. Swenson, et al. (1957) reported that supplemental trace minerals added to a dairy calf ration improved the growth rate after two weeks of age and lasted up to about eight weeks of age, having a tendency to level off. It increased the hemoglobin, hematocrit, and the number of erythrocytes.

In summary, we can say that when trace minerals were added to a roughage ration there was usually no response obtained. When added to fattening rations where the cereal grain was corn there was an improvement in performance that was not found when trace minerals were added when sorghum grain was the grain component of the ration.

EXPERIMENT I

In previous experiments at this station, there appeared to be an improvement in performance of animals on a corn, prairie hay, soybean meal and limestone fattening ration, when trace minerals were added. Bently et al. (1954) reported that cattle on this type of ration may be deficient in the trace element cobalt, since feed analysis of a similar ration in his experiment showed that the ration contained only .03 - .04 parts per million of cobalt. Poor quality hay has been reported by Glendening et al. (1952) and the National Research Council (1959).

This experiment was conducted to collect additional information on supplemental trace minerals added to a fattening ration of corn, prairie hay, soybean meal and limestone.

Methods and Procedure

The heifers used in the following experiment were purchased in the fall as calves from near Clovis, New Mexico and were wintered and summer grazed on blue stem pasture near Manhattan, Kansas prior to going on test.

The heifers were fed corn on pasture for about ten days before being moved to the feed lot to begin the experiment. Forty good to choice Hereford yearling heifers were divided into four lots, ten in each lot, on the basis of weight and previous treatment. Lots one and two were fed the control ration of corn, protein supplement, prairie hay, and ground limestone and lots three and four were fed the same ration with added trace minerals. The grain was self fed and the prairie hay was fed in

amounts readily eaten. The protein supplement, soybean oil meal, was fed once daily with the daily allowance of limestone added.

The trace minerals were supplied in a premix added to the soybean oil meal to furnish these quantities in milligrams per head daily: cobalt, 1.25; copper, 3.65; iodine, 1.97; iron, 46.13; manganese, 56.3; and zinc, 3.42.

The cattle were weighed twice at the start and the close of the experiment and averaged for a starting and final weight. They were weighed at approximately thirty day intervals during the trial. At the beginning of the experiment the cattle were fed the grain portion of their rations twice daily until they were receiving a full feed of grain and then they were self fed. Salt was available at all times, free choice, and limestone was fed at the rate of .1 pound per head daily to supply adequate calcium in the ration. A clean source of water was before the animals at all times. A shed opening to the south was on the north end of the lots and furnished shade to the animals. The fattening period was from August 7, 1958 to November 10, 1958, 95 days in length, at the close of which time the cattle were marketed in Kansas City, Missouri. Selling price was computed on the basis of carcass grade, weight, and carcass price. Feed prices used in computing the feed cost per 100 pounds of gain are listed in Table 1.

Carcass data was obtained by university personnel with the aid of the packing company's employees and the U.S.D.A. grader. U.S.D.A. grades were obtained from a government grader along with a marbling score, finish score, and size of rib eye score. Table 2 shows the descriptive terms used in the scoring and their numerical equivalent. The scores

were obtained by a visual view of the rib eye area at the 12th rib.

Table 1. Feed prices for experiment I and II

Feed components	Experiment I	Experiment II
Sorghum grain, cwt., ground	2.00	$ 2.10
Corn, cwt., ground	2.30	2.25
Soybean meal, ton	67.00	80.00
Prairie hay, ton	14.00	11.50
Salt, cwt.	1.20	1.10
Ground limestone, cwt.	1.00	1.00

Table 2. Carcass score sheet

Finish		Degree of Marbling	Size of ribeye
Thickness	Distribution		
1. Very thick	Very uniform	Very abundant	Very large
2. Thick	Uniform	Abundant	
3. Moderately thick	Moderately uniform	Moderately abundant	Moderately large
4. Modestly thick	Modestly uniform	Slightly abundant	Modestly large
5. Slightly thin	Slightly uneven	Moderate	Slightly small
6. Thin	Uneven	Modest	Small
7. Very thin	Very uneven	Small amount	Very small
8.		Slight amount	
9.		Traces	
10.		Practically devoid	

The following U.S.D.A. grades for beef cattle were used; prime, choice, good, standard, commercial, utility, cutter and canner. Each grade. Dressing per cent was determined by using live weight at Manhattan and hot dressed weight at Kansas City, Missouri.

One heifer died the first part of October; the cause of death was undetermined. Feed in the bunk at the time of death was weighed back and one animal's feed consumption up to that time was taken out. Foot rot was wide spread in all lots and animals were treated as it occured.

Results and Discussion

The heifers in the two non-treated lots, lots one and two, gained a total of 243 pounds and 254 pounds respectively, in 95 days and the heifers in the trace mineral treated lots gained 283 pounds and 277 pounds in 95 days. Smith et al. (1954) noticed that most of the improvement in a trace mineral fed lot, similar to these, was noticed in the first 30 days.

It was interesting to note that one control lot gained an average of 3.39 pounds per head daily, the other control lot, 2.42, for the first 33 days, while the two trace mineral fed lots gained 3.06 and 2.88 pounds respectively for the first 33 days of the experiment. A difference of only 0.06 pounds per head per day when the two different groups were averaged. At the end of 56 days, the control lots had gained an average of 3.11 pounds per head daily (lot 1) and 3.16 pounds per head daily (lot 3) and 3.64 pounds per head daily (lot 4). When averaged together, the control lots averaged 3.14 pounds per head daily, while the lots receiving trace minerals gained 3.47 pounds per head daily; a difference of 0.33 pounds per head daily in favor of the trace mineral lots for the

first 56 days of feeding nearly all of which occurred from the 33rd through the 56th day of feeding. Trace minerals increased the gains an average of 0.34 pounds per head per day for the 95 day feeding period which was statisticaly significant at the .05 level. The feed efficiency was only slightly improved over the control lots. An average of 675 pounds of corn was needed to produce 100 pounds of gain, for the control lots, while 637 pounds of corn was needed to produce 100 pounds of gain in the trace mineral lots, a difference of 38 less pounds of corn in favor of the trace mineral lots.

The carcasses graded approximately the same; however, carcasses from lot 3 (a trace mineral lot) graded slightly lower. The thickness of finish score, average marbling score, and the size of ribeye score were approximately the same for controls and trace mineral fed heifers.

Using the trace mineral analysis reported in Table 4, the copper and cobalt content of the rations were slightly below the recommended allowances of the National Research Council (1958b).

Maynard and Loosli (1956) recommended .1 milligram per 100 pounds of body weight of cobalt and 50 milligrams daily of copper. Using these figures, it appeared that possibly the corn, which when fed in large amounts as in a fattening ration, might be lacking in these trace minerals along with the roughage. According to tabular data of the National Research Council (1959) yellow corn was lower in all trace minerals than prairie hay, containing only one-seventh the amount of cobalt that prairie hay does, and approximately one-sixth the amount of copper. In reviewing the literature, trace minerals when added to a high roughage ration did not usually improve the performance of the animals; however, cattle that were placed on high corn rations with limited prairie hay did improve in

Table 3. The value of supplementary trace minerals in cattle fattening rations, experiment I. August 7, 1958 to November 10, 1958, 95 days.

Lot number	1	2	3	4
Number of heifers per lot	10	10	9[1]	10
Management	No supplementary trace minerals	No supplementary trace minerals	Trace minerals added[2]	Trace minerals added[2]
Initial wt. per heifer, lbs.	778	780	775	792
Final wt. per heifer, lbs.	1021	1034	1058	1069
Gain per heifer, lbs.	243	254	283	277
Daily gain per heifer, lbs.	2.56	2.67	2.98[3]	2.92[3]
Daily ration per heifer, lbs.				
Ground corn, self-fed	17.3	18.0	18.3	19.2
Soybean meal	1.5	1.5	1.5	1.5
Prairie hay	3.7	3.8	3.9	3.7
Salt	.05	.03	.04	.05
Ground limestone	0.10	0.10	0.10	0.10
Feed per cwt. gain, lbs.				
Corn	677	672	616	657
Soybean meal	59	56	50	51
Prairie hay	144	141	130	128
Cost of feed per cwt. gain[3]	18.60	18.38	$16.81	$17.78
Selling price per cwt.[4]	24.26	24.29	23.96	24.76
Dressing per cent	58.6	58.3	58.2	59.6
Carcass grades, U.S.D.A.:				
Low choice	1	3	0	2
High good	2	5	4	5
Ave. good	3	0	0	0
Low good	3	2	3	3
High standard	1	0	2	0
Av. thickness of finish,[5] score	3.9	3.8	3.8	4.1
Av. degree of marbling,[6] score	7.7	6.9	7.4	7.2
Av. size of ribeye,[7] score	4.3	4.2	4.2	4.5

[1]One heifer died, cause unknown.

[2]These quantities were fed in milligram per head daily: cobalt, 1.25; copper, 3.65, iodine, 1.97: iron, 46.13; manganese, 56.31 and zinc, 3.42

[3]Significant at the 5.0 per cent level over lots 1 and 2.

[4]See table for feed prices used.

[5]Selling price was computed on the basis of carcass grade, weight, and carcass price: choice, $42.50 /cwt.; high and av. good, $41.50, low good $41., and standard $40.50.

[6]Scores for thickness of finish: moderate, 3; modest, 4.

[7]Scores for degree of marbling: small amount, 7; slight amount, 8.

[8]Scores for size of ribeye: modestly large, 4; slightly small, 5.

Table 4. Trace minerals supplied by the rations in experiment I in milligrams per head daily.[1]

	Copper	Cobalt	Iodine	Iron	Manganese	Zinc
Lot 1 - Control lot.						
Corn, 17.3 lbs.	16.50	.55	2.04	243.47	219.91	168.86
Soybean meal, 1.5 lbs.	13.55	.25	1.02	122.58	16.44	35.75
Hay, 3.7 lbs.	7.90	.29		263.76	48.72	40.32
Total, mg.	37.95	1.09	3.06	629.81	279.07	244.93
Lot 2 - Control lot.						
Corn, 18.0 lbs.	17.16	.57	2.13	253.33	228.82	175.70
Soybean meal, 1.5 lbs.	13.55	.25	1.02	122.58	16.44	35.75
Hay, 3.8 lbs.	8.34	.30		278.68	51.48	42.60
Total, mg.	39.05	1.12	3.15	654.59	296.74	254.05
Lot 3 - Trace mineral lot.						
Corn, 18.3 lbs.	17.45	.58	2.16	257.55	232.62	178.62
Soybean meal and trace minerals, 1.5 lbs.	16.34	1.02	2.86	164.80	81.72	39.50
Hay, 3.9 lbs.	8.32	.30		278.05	51.36	42.50
Total mg.	42.11	1.90	5.02	700.04	365.70	260.62

[1]Trace mineral analysis of feeds fed in experiment II were used.

Table 4. (Concl.)

	Copper	Cobalt	Iodine	Iron	Manganese	Zinc
Lot 4 - Trace mineral lot.						
Corn, 19.2 lbs.	18.31	.61	2.27	270.23	244.80	187.42
Soybean meal and trace minerals, 1.5 lbs.	16.34	1.02	2.86	1[illegible]4.80	81.72	3[illegible].50
Hay, 3.9 lbs.	7.90	.29		263.76	48.72	4[illegible].24
Total, mg.	42.55	1.92	5.13	698.79	302.24	2[illegible]7.24

performance when trace minerals were supplied. This would indicate that possibly more attention should be placed on the mineral content of the cereal grain fed, than on the roughage.

EXPERIMENT II

This station and others have reported there was no advantage to adding supplementary trace minerals to a fattening ration in which the cereal grain was sorghum grain. Baker et al. (1955, Pope et al. ([illegible]), Sellers et al. (1960), Smith and Cox (1953) and Oltjen et al. (1959) all reported that there was no response from trace minerals added to a sorghum grain fattening ration.

When corn was the cereal grain in the fattening ration, added trace minerals improved the performance of the cattle by an average daily gain of 0.47 pounds per head, and less feed was required to produce 100 pounds of gain, according to Oltjen, et al. (1959). Other workers at Ohio have shown considerable improvement when certain trace elements were added to a corn fattening ration. Klosterman et al. (1953) and (1956) reported

that cattle receiving trace minerals improved their daily gain by an average of 0.24 pounds per head daily. Bently et al. (1952) and (1959) working at the same station found that trace minerals would improve daily gains up to 0.62 pounds per head daily, an increase in gain by 46 per cent and that they would also improve the feed efficiency.

Experiment I reported here, showed that trace minerals would improve the daily gain by an average of 0.34 pounds per head daily.

Since more attention, apparently, needed to be pointed toward the grain, in so far as trace minerals were concerned, this experiment was planned so that sorghum grain and corn, fed in a fattening ration, with and without trace minerals could be compared

Methods and Procedure

The heifers used in this experiment were purchased as calves, in the fall, from near Ft. Davis, Texas. They were wintered and then summer grazed on bluestem pastures prior to this test.

Lots 1 and 2 were fed a ration of ground corn, soybean meal, prairie hay and ground limestone and lot 2 received supplemental trace minerals. Lots 3 and 4 were fed a ration of ground sorghum grain, soybean meal, prairie hay and ground limestone and lot 4 received supplemental trace minerals.

The trace minerals were supplied in a premix added to the soybean meal to furnish these quantities in milligrams per head daily: cobalt, 1.25; copper, 3.65; iodine, 1.97; iron, 46.13; manganese, 56.3 and zinc. 3.42

The cattle were weighed at the pasture after an overnight stand,

hauled into the feed lots and weighed again after approximately 48 hours. The initial starting weight was the average of the two weights. The final weight was the average of two weights taken the last two days of the experiment. The cattle were weighed at intervals of 31, 25, 28, and 19 days.

At the beginning of the experiment the cattle were fed the concentrate portion of their ration twice daily. For approximately three weeks the daily grain portion of the ration was gradually increased until the cattle appeared to be leveling off in consumption. At this time daily feeding ceased and the feed was placed in the bunks in large quantities as needed. As the grain increased the cattle consumed less hay, and it was fed in amounts readily eaten after the heifers were on grain self-fed. Salt was available to the animals at all times and limestone was fed at the rate of .1 pound per head per day in the soybean meal to supply adequate calcium. An automatic type watering system was in each lot and was cleaned daily. The cattle had access to a shed on the north side of the lot, which opened to the south. The fattening period lasted from July 25, 1959 to November 6, 1959, a total of 104 days in length. The cattle were marketed at St. Joseph, Missouri at the close of the experiment. Selling price per 100 pounds live weight was computed on the basis of carcass grade, weight, and carcass price. Feed prices used in computing feed cost per 100 pounds gain are reported in Table I.

Carcass data was obtained by university personnel with the aid of the packing company's employees. A U.S.D.A. grader scored the animals as to grade and degree of marbling. The marbling score and size of ribeye was obtained from the ribeye area at the twelfth rib. A ribeye tracing

was made at the time and later measured by use of a planimeter to determine the number of square inches in the ribeye area per animal. U.S.D.A. grades for beef cattle were used as follows: prime, choice, good, standard, commercial, utility, cutter, and canner. Each grade was divided into a third of a grade as follows: high, average, and low for each grade. The terms used to describe carcass quality are listed in Table II. Dressing per cent was determined by using live weight at Manhattan and hot dressed weight at St. Joseph, Missouri.

Two heifers were removed from the experiment. One heifer from the sorghum grain plus trace mineral lot was removed due to unthriftiness on October 3 and one heifer from the sorghum grain control lot at the end of the feeding period due to founder.

Results and Discussions

The results of experiment II are reported in Table 5. The addition of the trace mineral mixture to the corn grain fattening ration increased the gain of the heifers 0.56 pounds per head daily. This difference in gain when tested by analysis of variance, Snedecor (1956), was significantly greater at the .05 level. The lots receiving sorghum grain made an average daily gain of 250 pounds for the control lot and 2.83 for the trace mineral lot, a difference of 0.33 pounds per head daily. This difference was also found to be significant at the .05 level. It is of interest that this was the first time that animals receiving a fattening ration of sorghum grain with added trace minerals had shown a significant response.

In addition of trace minerals to the corn ration increased the feed efficiency, it took 129 pounds less corn to obtain 100 pounds gain for the

Table 5. Supplementary trace minerals in cattle fattening rations. July 25, 1959 to November 6, 1959 - 104 days

Lot number	1	2	3	4
Number heifers per lot	10	10	9[1]	9[2]
Management	No supplementary trace minerals	Trace minerals added	No supplementary trace minerals	Trace minerals added
Initial wt. per heifer, lbs.	608	599	604	605
Final wt. per heifer, lbs.	850	900	864	900
Gain per heifer, lbs.	242	301	260	295
Daily gain per heifer, lbs.	2.33	2.89[3]	2.50	2.83[3]
Daily ration per heifer, lbs.:				
Corn	15.25	15.21		
Sorghum grain			17.28	18.24
Soybean meal	1.5		1.5	
Soybean meal and trace mineral		1.5		1.5
Hay	4.48	4.49	4.49	4.70
Ground limestone	.1	.1	.1	.1
Salt	.05	.05	.06	.05
Feed per cwt. gain, lbs.[4]				
Corn	655.4	525.5		
Sorghum grain			691.2	643.0
Protein	64.5	51.8	60.0	47.7
Hay	193.2	155.2	196.0	165.7
Dressing per cent	57.18	57.31	57.98	57.32
Carcass grades, USDA:				
Low choice	0	0	0	2
High good	2	6	3	1
Average good	5	3	2	4
Low good	2	1	3	2
High standard	1	0	1	0
Average degree of marbling, score.[6]	7.8	7.3	7.6	7.3
Average size of ribeye, sq. in.	9.76	10.39	10.16	9.92
Selling price per cwt., dollars.[5]	22.22	22.35	22.52	22.48
Cost of feed per cwt. gain, dollars.[4]	18.45	14.79	18.05	16.58

[1]One heifer was removed due to founder.

[2]One heifer was removed due to unthriftiness.

[3]Gains significantly greater at .05 level for lot 2 over 1, and lot 4 over 3.

[4]See table 1 for feed prices.

[5]Selling price was computed on the basis of carcass grade, weight, and carcass price: choice, \$40 per cwt.; good \$39; standard, \$37.50.

[6]Scores for degree of marbling: small amount 7; slight amount 8.

corn trace mineral lot than the control lot, or almost one fifth less, indicating that although the daily consumption was approximately the same, the animals fed the trace minerals utilized their grain more efficiently. The heifers in the sorghum grain trace mineral lot also used this feed more efficiently, which was the first time this has been reported at this station. They required 48 pounds less grain to put on 100 pounds gain than the control lot, indicating that while they consumed almost a pound per day more grain, they used it slightly more efficiently than the control lot. Trace mineral addition to the sorghum grain ration apparently improved the appetite of the heifers.

When the carcasses were compared, there were no large differences in grade, marbling score, or size of ribeye. Both lots receiving trace minerals graded slightly higher but the difference was less than one-third of a grade. The marbling scores were slightly higher for the lots receiving the trace mineral rations. The size of the ribeye area was conflicting. The corn trace mineral lot had 0.63 square inches more area than did the control lot, while with the sorghum grain control lot had 0.24 square inches more than the trace mineral lot.

The greatest improvement in gain of the heifers receiving the corn fattening ration and trace minerals occurred between the 33rd and 84th days, as was found in experiment I. At the end of 31 days of feeding the corn lot had gained 3.32 pounds per head daily, and the corn trace mineral lot 3.90 pounds per head daily, a difference of 0.58 pounds but during the next 25 days of feeding the corn control lot gained an average of 2.24 pounds per head daily and the corn plus trace mineral lot gained an average of 3.48 pounds, a difference of 1.24 pounds per head

daily. The corn control lot gained 0.54 pounds per head daily during the next 28 days, while the trace mineral lot gained 1.54 pounds a difference of 1.00 pounds per head daily. During the last 20 days of the experiment the control lot outgained the trace mineral lot by 0.90 of a pound per head daily. No explanation could be found for this except that gains over short periods do fluctuate and to much emphasis probably should not be placed on them.

The sorghum grain lot plus trace minerals showed most improvement during the last 73 days of the experiment. At the end of the first 31 days of feeding the control cattle had gained 3.45 pounds per head daily, and the trace mineral lot 3.19, a difference of .25 pounds in favor of the control lot. During the next 25 days the control lot gained 2.84 pounds per head daily, and the trace mineral lot gained 3.28 pounds. The trace mineral lot gained .44 pounds more per head daily. The following 28 days the controls gained 1.79 pounds per head daily, while the trace mineral lot gained 2.07 pounds, a difference of .28 pounds. The last 20 days of the trail the controls gained only 2.15 pounds while the trace mineral lot gained 3.30 pounds, or 1.15 pounds per head daily more for the lot receiving supplemental trace minerals.

Nelson et al. (1952) of Oklahoma found that the blood picture was not altered when trace minerals were added to a ration of corn gluten meal, prairie hay (free choice), salt, and dicalcium phosphate, while Swenson et al. (1957) feeding a ration of colostrum, whole milk, calf starter, grower ration and alfalfa hay reported that the number of red blood cells was increased along with the hemoglobin content and hematocrit when trace minerals were fed. Swenson and Underbjerg (1953)

reported that the blood picture was not significantly changed by the addition of trace minerals.

In this experiment it was thought that it might be advantageous to study the hemogram of the individuals in each lot to see if any differences existed between the lots. Blood samples were taken October 14, 1959 and were processed by the Physiology Department and are presented in Table 6.

Dukes (1955) stated that the normal hematocrit reading for cattle was 40 milliliters of red blood cells per 100 milliliters of blood. All of the cattle in this experiment were below this level. The normal hemoglobin content for cattle was 12.3 grams per 100 milliliters of blood. These samples on the average were considerably lower than normal, the highest being 8.73 grams per 100 milliliters of blood. The number of red blood cells found normally in beef cattle was 6 - 8 millions per cubic millimeter of blood, all of the lots were within this range. The white blood cell count normally ranged from 5 - 12 thousand per cubic millimeter of blood. All lots were considerably below this level. Swenson and Underbjerg (1953) stated the average values for 24 Hereford heifers in their work resulted in a mean corpuscular value of 48.8, and mean corpuscular hemoglobin value of 14.4. With this in mind, there was an indication that perhaps all lots were suffering from a slight microcytic hypochromic anemia, indicating that copper and iron might be lacking or needed in different ratios, or possibly a parasitic condition existed.

Feed was collected three times per week and the composite feed sample analyzed for dry matter, protein, ether extract, crude fiber

Table 6. Hemogram of heifers in experiment II

Sample no.	Animal no.	Ht.[1]	Hb.[2]	RBC.[3]	WBC.[4]	MCV.[5]	MCH.[6]	MCHC.[7]
Lot 1, Corn with no trace minerals added.								
1	25	35	8.25	8440	11500	41.47	9.77	23.57
2	99	37	8.25	8490	9750	43.58	9.72	22.30
3	58	45	9.8	8560	9050	52.57	11.45	21.78
4	117	39	8.9	7240	10200	53.87	12.29	22.82
5	31	40	9.25	8800	10500	45.45	10.51	23.13
6	49	36	8.0	7720	8400	46.63	10.36	22.22
7	55	36	8.5	8660	11700	41.57	9.82	23.61
8	11	37	8.5	7540	7500	49.07	11.27	22.97
9	108	34.5	8.0	8700	10000	39.66	9.20	23.19
10	40	36.5	8.25	7350	9900	49.66	11.22	22.60
Average		37.6	8.57	8150	9850	46.35	10.54	22.82
Lot 2, Corn with trace minerals added.								
11	8	37	8.25	6530	10400	56.66	12.63	22.30
12	22	36	7.75	8930	11050	40.31	8.68	21.53
13	100	42	9.3	7960	9600	52.76	11.68	21.63
14	75	36	8.25	9970	8900	36.11	8.27	22.92
15	126	33.5	8.0	7230	5950	46.33	11.07	23.88
16	35	35.5	8.0	7870	9000	45.11	10.17	22.54
17	53	40	9.25	7660	11500	52.22	12.08	23.13
18	113	41	9.3	8430	10500	48.64	11.03	22.68
19	66	42.5	8.9	7960	7000	53.39	11.18	20.94
20	74	40	9.25	8790	7650	45.51	10.52	23.13
Average		38.4	8.73	8133	9155	47.50	10.73	22.47

[1]Ht. - milliliters R.B.C. per 100 milliliters blood.
[2]Hb. - grams per 100 milliliters blood.
[3]RBC. - millions per cubic millimter of blood.
[4]WBC. - thousands per cubic millimeter of blood.
[5]MCV. (cubic micron) - $\frac{\text{volume packed RBC., milliliters, per 1000 milliliter}}{\text{RBC., millions per cubic millimeters}}$
[6]MCH. (micro-micro grams) - $\frac{\text{Hb., grams, per 1000 milliliter}}{\text{RBC., Millions per cubic millimeters.}}$
[7]MCHC. (per cent) - $\frac{\text{Hb., grams, per 100 milliliter X 100}}{\text{Volume packed RBC., milliliters per 100 milliliter.}}$

Table 6. (Concl.)

Sample no.	Animal no.	Ht.	Hb.	RBC.	WBC.	MCV.	MCH.	MCHC.
Lot 3, Sorghum grain with no trace minerals added.								
21	86	32	7.25	6280	10900	50.96	11.54	22.66
22	119	42	9.5	6720	18300	62.50	14.14	22.62
23	37	41	9.25	8490	7850	48.29	10.90	22.56
24	10	32	7.25	9050	15800	35.36	8.01	22.66
25	48	44	10.1	8910	7300	49.38	11.34	22.95
26	87	35	7.9	9130	6400	38.34	8.65	22.57
27	68	34	7.75	7650	7650	44.44	10.13	22.79
28	107	37.5	8.25	8080	6300	46.41	10.21	22.00
29	124	39	8.9	7570	10100	51.52	11.76	22.82
30	21	34	8.0	8010	9550	42.45	9.99	23.53
Average		37.1	8.24	7989	9975	46.97	10.67	22.72
Lot 4, Sorghum grain with trace minerals added								
31	84	32	7.5	5[illegible]40	6900	59.53	14.04	23.44
32.	64	38	8.75	8640	9300	43.98	10.13	23.03
33	67	35	8.3	6980	10100	50.14	11.89	23.71
34	18	41	9.25	8630	8850	47.51	10.72	22.56
35	65	38	8.5	8880	11000	42.79	9.57	22.37
36	29	41	9.3	7890	10100	51.96	11.79	22.68
37	111	38	8.9	7640	11150	49.73	11.65	23.42
38	44	43	9.5	6680	9050	64.37	14.22	22.09
39	69	39	8.75	9030	10900	43.19	9.69	22.44
40	39	33	8.25	7300	8200	45.21	11.30	25.0
Average		37.8	8.7	7701	9975	49.88	11.5[illegible]	23.07

and ash, according to A.O.A.C (1955) methods. These analysis are reported in Table 7. All analysis were in close agreement with Morrison (1959).

Table 7. Proximate feed stuff analysis of feeds used in experiment II.

	Dry matter %	Protein %	Ether extract %	Crude fiber %	Ash %
Corn	86.2	11.0	4.8	3.1	1.7
Sorghum grain	86.1	11.1	2.1	2.3	2.0
Prairie hay	93.3	6.2	2.1	34.6	7.5
Soybean meal	89.2	50.1	1.9	6.1	7.5

In addition to the regular feed stuff analysis the feeds were analyzed for the following trace minerals; copper, cobalt, iodine, iron, manganese and zinc. These analyses are reported in Table 8.

When trace minerals were supplied the cobalt content was within the recommended amount while the copper content was still below the 50 milligrams recommended by Maynard and Loosli (1956)

This possibly indicates that the levels added of certain trace minerals, such as copper, may not have been in sufficient amounts to meet the requirements of the animals. It was of interest that the sorghum grain contained more of each trace mineral than corn, possibly indicating the reason that no response from added trace minerals prior to this experiment had been obtained at this station. Corn and sorghum grain were lower in cobalt than prairie hay, which according to Bently et al. (1954) might be the limiting factor in a corn and poor quality hay fattening ration. A comparison of the trace mineral content of feeds from different sources

Table 8. Trace mineral analysis of ration components[1]

	PPM Copper	PPM Cobalt	PPM Iodine	PPM Iron	PPM Manganese	PPM Zinc
Corn	2.1	.07	.26	31	28	21.5
Sorghum grain	2.0	.12	.26	102	25	14.5
Prairie hay	4.7	.17		157	29	24
Soybean meal	19.9	.36	1.5	180	24	52.5
Soybean meal and trace minerals	24	1.5	4.2	242	120	58
Calcium carbonate	1.8	.5	8.9	460	398	20.5
Salt	3.1	.5		167	56	7.5
Water	.004	.008		6.7	.5	.06

[1]Supplied by the Calcium Carbonate Company, Chicago Illinois.

is reported in Table 9. The trace mineral amounts supplied by each ration are presented in Table 10. These calculated rations furnish evidence that copper along with cobalt was slightly deficient in both the corn and sorghum grain rations in this experiment, according to the National Research Council (1958B) and Maynard and Loosli (1956). The iodine, iron, manganese and zinc recommendation appear to have been met by the feeding of the control rations.

SUMMARY

A total of 40 yearling heifers were used in experiment I, two lots of ten heifers each served as controls and two lots of ten heifers each were fed rations identical to the controls except the following trace minerals were added to the ration; copper, cobalt, iron, zinc and manganese.

In this experiment there was a response from adding trace minerals to the ration consisting of ground yellow corn (self-fed), soybean oil meal, prairie hay, ground limestone, and salt. The addition of trace minerals increased the daily gain on an average of .34 pounds per head daily which was statistically significant at the .05 level, with only a slight improvement in feed efficiency. It was noted that the animals made most of their improvement during the 33rd through 75th day of a 95 day feeding period. In general the carcasses were about the same. Using a trace mineral analysis of the feeds fed in experiment II, the copper and cobalt content were slightly deficient according to the recommended allowances of the National Research Council (1958B).

The increase in daily gain was slightly less than the 0.47 additional

Table 9. Trace mineral content of feeds as reported in the literature.

	Copper				Cobalt				Manganese				Iron				Zinc			
	N.R.C. (1958)	N.R.C. (1959)	Glendening (1952)	Carmack (1960)	N.R.C. (1958)	N.R.C. (1959)	Glendening (1952)	Carmack (1960)	N.R.C. (1958)	N.R.C. (1959)	Glendening (1952)	Carmack (1960)	N.R.C. (1958)	N.R.C. (1959)	Glendening (1952)	Carmack (1960)	N.R.C. (1958	N.R.C. (1959)	Glendening (1952)	Carmack (1960)
Corn	1.8	2.2	4.0	2.1	.039	.01	.23	.07	2.2	2.9	9.0	28	.003	5.5	.004	31	5.5	9.0	--	21.5
Sorghum grain, all analyses	4.9	4.9	14.0	2.1	.138	.14	.14	.12	7.4	7.4	16.	25	.005	7.0	.002	102	7.0	22	--	14.5
Prairie hay	12.8	12.8	25	4.7	.072	.07	.17	4.7	32.8	32.8	53	29	.012	.55	.012	157	--	--	--	24

Table 1[illegible]. Trace minerals su plied b the rations in experiment II. In milligrams per head daily.

	Copper	Cobalt	Iodine	Iron	Manganese	Zinc
Lot 1 - Corn						
Corn, 15.25 lbs.	14.539	.4[illegible]5	1.800	214.629	193.858	148.855
Soybean meal 1.5 lbs.	13.552	.245	1.022	12[illegible].580	16.344	35.753
Hay, 4.48 lbs.	9.559	.346		319.325	58.984	48.814
Limestone, .1 lbs.	.082	.023	.4[illegible]4	2[illegible].884	18.069	.931
Salt, .05 lbs.	.070	.011		3.7[illegible]1	[illegible].271	.170
Water, 1 gal. /cwt. body	.116	.023		193.915	14.471	1.737
Total, mg.	37.918	1.133	3.226	875.124	3[illegible]2.997	236.259
Lot 2 - Corn with added trace minerals						
Corn, 15.21 lbs.	1[illegible].501	.483	1.795	214.066	193.350	148.465
Soybean meal and trace minerals, 1.5 lbs.	16.44	1.022	2.860	164.802	81.720	39.498
Hay, 4.49 lbs.	[illegible].581	.347		320.038	59.115	48.923
Limestone, .1 lbs.	.082	.023	.405	20.884	18.069	.931
Salt, .05	.072	.012		3.866	1.296	.174
Water, 1 gal. / 100 lbs. body cwt.	.119	.024		198.478	14.812	1.777
Total, mg.	4[illegible].698	1.909	5.060	922.133	368.362	239.768

Table 10. (Concl.)

	Copper	Cobalt	Iodine	Iron	Manganese	Zinc
Lot 3 - Sorghum grain						
Sorghum grain, 17.28 lbs.	16.475	.941	2.040	800.202	196.128	113.754
Soybean meal, 1.5 lbs.	13.552	.245	1.022	122.580	16.344	35.753
Hay, 4.90 lbs.	10.456	.378		349.262	64.513	53.390
Limestone, .1 lbs.	.082	.023	.404	20.884	18.069	.931
Salt, .06 lbs.	.081	.013		4.367	1.464	.196
Water, 1 gal. / 100 lbs. body wt.	.116	.023		193.915	14.471	1.747
Total, mg.	40.761	1.624	3.465	1491.210	310.990	205.760
Lot 4 - Sorghum grain with added trace minerals						
Sorghum grain, 18.24 lbs.	16.562	.994	2.153	844.658	207.024	120.074
Soybean meal and trace	16.344	1.022	2.860	168.802	81.720	39.498
Hay, 4.70 lbs.	10.029	.363		335.007	61.880	51.211
Limestone .1 lbs.	.082	.023	.404	20.884	18.069	.931
Salt .05 lbs.	.065	.010		3.487	1.169	.157
Water, 1 gal. / 100 lbs. body wt.	.119	.024		198.478	14.812	1.777
Total mg.	43.200	2.435	5.417	1567.315	384.674	213.649

pounds of gain per head daily reported by Oltjen et al. (1959) at this station, or by Bently et al. (1954), who reported an increase in daily gain of 0.62 pounds.

In this experiment, it may be concluded that when corn, soybean meal, prairie hay, ground limestone and salt were used in a fattening ration, the addition of certain trace minerals (copper, cobalt, manganese, iodine, iron and zinc) were of definate value in as far as daily rate of gain and feed efficiency were concerned.

Previous work at this station by Smith et al. (1953), Oltjen et al. (1959), and work by Pope et al. (1959) at Oklahoma have reported that there appeared to be no advantage in adding trace minerals to a sorghum grain fattening ration. However animals fed rations with corn as the grain in the fattening ration have shown a definate response to the addition of supplemental trace minerals when the remainder of the ration has been prairie hay, soybean meal and ground limestone.

It was thought that it might be of value to compare within the same year a ration of sorghum grain, prairie hay, soybean meal and limestone with a ration where corn replaced sorghum grain and to feed these two rations with and without supplementary trace minerals.

In experiment II, forty yearling heifers were divided into four lots and fed as outlined above.

For the first time at this station, trace minerals when added to a sorghum grain fattening ration improved the performance of the animals. Trace minerals added to a corn fattening ration also improved the performance as found in experiment I and in other experiments.

The heifers in the sorghum grain trace mineral lot gained an ad-

ditional .33 pounds per head daily and the feed efficiency was also improved. The additional of trace minerals to the ration improved the appetite as noted by the daily intake. The heifers fed the corn and trace minerals gained an additional 0.56 pounds more per head daily than those receiving corn and no trace minerals and had a considerably improvement in feed efficiency, requiring 129 pounds less corn to produce 100 pounds of gain. The gains made b either lot receiving trace minerals were statistically significant.

The carcass data was in general about the same; although, the carcasses of the heifers in both trace mineral lots graded slightly higher.

The heifers fed sorghum grain and trace minerals made their greatest improvement during the last 73 days of the experiment. The heifers fed corn and trace minerals made their greatest improvement in performance from the 33rd to the 84th day of the experiment, contrary to work done by Smith et al. (1954) and Swenson et al. (1957), who reported that the larger part of the improvement was more noticeable at the close of the first six to eight weeks. A hemogram indicated that certain components of the blood were approximately the same in all four lots; low in hemoglobin, white blood cells, hematocrit, and high in red blood cells. This indicated possibly that the amounts of certain trace minerals were insufficient or that they are needed in different ratios of concentrations in all lots. Much more work must be done before it will be possible to explain the variations found to occur from time to time in experiments such as these.

A trace mineral analysis of the feed indicated that copper and

and cobalt were slightly deficient in the lots not receiving trace minerals according to the recommended amounts of the National Research Council (1958B) and Maynard and Loosli (1956). The copper content of the rations where supplementary trace minerals were included was still below the recommended level.

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THE VALUE OF SUPPLEMENTAL TRACE MINERALS IN CATTLE FATTENING RATIONS

by

BOBBY DERYLE CARMACK

B. S., Oklahoma Panhandle
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It is commonly believed that there are no trace mineral deficiency in Kansas cattle rations. Feed analysis of the different components of rations usually fed to cattle have also indicated that there probably are no trace mineral deficiency problems. It is very probable that while this may be true, the trace minerals supplied by the ration may not be in a readily available form or may be needed in different ratios to supply the body with the necessary amounts. These experiments were designed to determine the need and effects of supplemental trace minerals in fattening rations containing the two most commonly used cereal grains in Kansas, corn and sorghum grain. The supplementary trace elements supplied were: copper, cobalt, iron, iodine, manganese, and zinc.

Eighty head of good to choice Hereford heifers were used in these experiments, alloted in lots of ten each according to weight and previous treatment. The trace minerals were supplied in a premix added to the soybean meal.

In experiment I, four lots of heifers were fed rations of ground yellow corn, soybean meal, prairie hay, ground limestone, and salt which was offered free choice. Two of these lots were supplied with supplemental trace minerals. The feeding period was 95 days in length.

In summarizing experiment I, the addition of trace minerals to a corn fattening ration had a definite value. The daily gain was significantly increased an average of 0.34 pounds per head with a slight increase in feed efficiency when trace minerals were added. In general the carcass data were approximately the same.

In experiment II, four lots of heifers were divided into two groups, two lots in each group. One group received a ration of ground yellow

corn, soybean meal, prairie hay, ground limestone, and salt offered free choice. The other group received the same ration, but sorghum grain was substituted for corn. One lot in each group received supplemental trace minerals. The length of the feeding period was 104 days.

In this experiment, the addition of trace minerals to the corn fattening ration improved the average daily gain per heifer significantly by 0.56 pounds with an improvement in feed efficiency. Trace minerals when added to the sorghum grain fattening ration improved the average daily gain per heifer significantly by 0.33 pounds with a slight improvement in feed efficiency. Carcass data were approximately the same for all lots receiving either grain. A hemogram of the heifers from each lot indicated that all animals were slightly anemic. A trace mineral analysis of the feed showed that sorghum grain was higher in each trace mineral compared to corn. Copper and cobalt appeared to be slightly deficient in the control rations. Even with supplemental trace minerals added, the ration was below recommended allowance for copper.